

DESCRIPTION**MULTIFUNCTION-TYPE VIBRATION ACTUATOR AND MOBILE
TERMINAL DEVICE****TECHNICAL FIELD**

[0001]

This invention relates to a multifunction-type vibration actuator mounted on a mobile terminal device, such as a mobile phone and a small information communication terminal, and alerts a user to an incoming call with sound or vibration by one device and a mobile terminal device mounted with that actuator. More specifically, this invention relates to a multifunction-type vibration actuator of which a housing accommodates a magnetic circuit part, a suspension for elastically supporting the magnetic circuit part in the housing, a diaphragm arranged facing the magnetic circuit part, and a voice coil provided to the diaphragm and inserted into a magnetic gap of the magnetic circuit part, wherein an input of a signal with a vibration frequency to the voice coil allows vibration of the suspension securing the magnetic circuit part to be transmitted outward through the housing.

BACKGROUND ART

[0002]

Conventionally, this type of multifunction-type vibration actuator has a yoke (magnetic yoke) where a magnetic circuit part is fitted and secured in a central opening of a suspension, and a plurality of equally spaced tongues provided to an outer periphery of the suspension are fitted and bonded in stepped notches inside a frame of a housing (enclosure) in order to secure the outer periphery to the housing. (See, for example, Patent Reference 1). In this actuator, input of voice signal current to the voice coil initiates vibration of the diaphragm to generate a sound, such as an incoming call alert, melody, voice, or music, and input of a signal with a vibration frequency initiates vibration of mechanical vibration systems consisting of the magnetic circuit part and the suspension to transmit this vibration throughout a mobile terminal device mounted with this multifunction-type vibration actuator through the housing.

Moreover, we find another multifunction-type vibration actuator in which a yoke (lower yoke) of a magnetic circuit part is fitted and secured in a central opening of a suspension (leaf spring) by laser welding and an outer periphery of the suspension is inserted and secured between a housing (case) and a spacer fitted inside the housing. (See, for example, Patent Reference 2.)

[0003]

[Patent Reference 1] JP2002-191092 A (Figs. 8-11 on Page 2)

[Patent Reference 2] JP11-7286A (Figs. 2 and 3 on Page 3-5)

DISCLOSURE OF THE INVENTION

PROBLEM SOLVED BY THE INVENTION

[0004]

In this type of multifunction-type vibration actuator, it is necessary to precisely control the characteristics of the suspension and a vibration body consisting of the magnetic circuit part and suspension in order to accurately tune the vibration frequency of the suspension. The characteristics of the suspension vary depending on the slight difference in materials or dimensional accuracy for each manufacturing lot, and the weight of a magnet or a yoke configuring the magnetic circuit part also varies slightly depending on the dimensional accuracy for each manufacturing lot. In a conventional multifunction-type vibration actuator, however, since the suspension is bonded to the magnetic circuit part with adhesive or by laser welding in the desired position, the distance between this bonding position and the secured position of the suspension in the housing is always constant. Thus, it was difficult to tune the vibration frequency of the suspension in the assembly stage. As a result, a shift in the vibration frequency from the targeted value lowers the acceleration during actual operation, and variation in part processing accuracy destabilizes the quality of the finished product, leading to high manufacturing costs.

[0005]

The invention according to Claim 1 and the invention according to Claim 3, quoting Claim 1 among these inventions, have the purpose of accurately tuning the vibration frequency of the suspension during assembly. The invention according to Claim 2 and the invention according to Claim 3, quoting Claim 2, have the purpose of enabling rapid and accurate positioning while realizing a simple tuning construction in addition to the purpose of the invention according to Claim 1.

MEANS FOR SOLVING THE PROBLEM

[0006]

In order to achieve the aforementioned purposes, the invention according to Claim 1 among these inventions provides a multifunction-type vibration actuator, wherein a plurality of secured positions for the magnetic circuit part and the suspension are prepared so as to be close to each other, and a distance between the secured position and a central vibration position of the suspension and the housing is changed by selecting secured positions suitable for a characteristic of the suspension to be mounted and

suitable also for a weight of the magnetic circuit part from the secured positions and by using the secured position. The invention according to Claim 2 provides a multifunction-type vibration actuator, wherein the configuration of the invention according to Claim 1 is added with a configuration where the above-described secured positions are through-holes for laser welding opened in a suspension and laser welding is performed by changing the laser radiation positions toward the through-holes. The invention according to Claim 3 provides a mobile terminal device incorporating a multifunction-type vibration actuator according to Claim 1 or 2, wherein receiving a call-out signal initiates vibration of the diaphragm and one or both mechanical vibration systems, consisting of a magnetic circuit part and a suspension in order to transmit the vibration of the mechanical vibration systems throughout a device through a housing and reset of the call-out signal, stops vibration of the diaphragm and the mechanical vibration systems.

EFFECTS OF THE INVENTION

[0007]

In the invention according to Claim 1 and the invention according to Claim 3, quoting Claim 1, among these inventions, a plurality of secured positions for the magnetic circuit part and the suspension are prepared so as to be close to each other, and a distance between the securing planned position and a central vibration position of the suspension and the housing is changed by selecting secured positions suitable for a characteristic of the suspension to be mounted and suitable also for a weight of the magnetic circuit part from the secured positions and by using the secured position in order to enable tuning to the desired frequency. Therefore, it is possible to accurately tune the vibration frequency of the suspension during assembly. As a result, variation in the accuracy of parts for the suspension or the magnetic circuit part, depending on each manufacturing lot, is restricted to stabilize the quality of the finished product, leading to a reduction in the manufacturing costs.

[0008]

In the invention according to Claim 2 and the invention according to Claim 3, quoting Claim 2, laser welding is performed by changing the laser radiation positions toward the through-holes 3e in order to enable rapid and accurate positioning while realizing simple tuning construction in addition to the effect of the invention according to Claim 1. Therefore, it is possible to perform rapid and accurate positioning while realizing a simple tuning construction. As a result, the manufacturing costs can be further reduced.

BEST MODE FOR CARRYING OUT THE INVENTION

[0009]

Now, an embodiment of the invention is described based on drawings. In a multifunction-type vibration actuator A according to the invention, a cylindrical housing 1 accommodates a magnetic circuit part 2, a suspension 3 for elastically supporting a magnetic circuit part 2 upward, a diaphragm 4 facing a magnetic circuit part 2, and a voice coil 5 bonded to a diaphragm 4 and inserted into an annular magnetic gap 2a of a magnetic circuit part 2 as shown in Figs. 1 through 5, and input of a voice signal to a voice coil 5 initiates low vibration of a diaphragm 4 to generate a sound, such as an incoming call alert, melody, voice, or music, and an input of signal current with a vibration frequency of 120 – 160 Hz initiates high vibration of heavy mechanical vibration systems consisting of a magnetic circuit part 2 and a suspension 3.

[0010]

A housing 1 is a cylindrical enclosure for accommodating a magnetic circuit part 2, on an open end 1a (the top in the drawing) of which an outer peripheral portion 4a of a diaphragm 4 is bonded with adhesive, and another open end 1b (the bottom in the drawing) is detachably provided with and covered by a bottom cover 6.

[0011]

An outer circumferential portion 3a of a suspension 3 bonded to a magnetic circuit part 2 and an elastically deformable annular member 7 are inserted between the other open end 1b of a housing 1 and a cover 6 in order to press an outer circumferential portion 3a of a suspension 3 onto the other open end 1b of a housing 1.

[0012]

This annular member 7 is an O-ring made of an elastic material, such as synthetic rubber, and arranged along an outer periphery at the bottom of a cover 6 facing an outer circumferential portion 3a of a suspension 3 as shown in Figs. 1, 3 and 5. Furthermore, it is preferable to select an optimum annular member 7 from those with different thicknesses and hardness numbers.

[0013]

Fitting portions of a housing 1 and a cover 6 are provided with an engaging means 8 for securing the positioning. In this embodiment, a lower peripheral side wall 1c is formed so as to be fitted in a side peripheral wall 6a of a cylindrical cover 6 with a bottom and a plurality of engaging protrusions 8a and engaging slits 8b as the aforementioned engaging means 8 are provided to these fitting surfaces for each circumferentially and equally spaced location as shown in Figs. 3 and 5.

[0014]

Although an outer diameter of a lower peripheral side wall 1c of a housing 1 is designed slightly smaller than an inner diameter of a side peripheral wall 6a of a cover 6 to fit to

each other, the engaging protrusions 8a are provided to an outer surface of a lower peripheral side wall 1c of a housing 1, and the engaging slits 8b are penetratingly provided to an inner surface of a side peripheral wall 6a of a cover 6 as shown in the drawing, the fitting construction and the shape of an engaging means 8 are not limited to those shown in the drawing, and other constructions and shapes, for example, arrangement of the engaging protrusions 8a and the engaging slits 8b opposite to that shown in the drawing, are acceptable if similar functions are available.

[0015]

A suspension 3 is an annular leaf spring to the central section of which a central opening 3b to be fitted to a magnetic circuit part 2 to be described later, an annular portion 3c surrounding this central opening 3b in contact with a magnetic circuit part 2, and a deflectable arm 3d communicating the annular portion 3c and an outer circumferential portion 3a are provided, wherein the annular portion 3c is integrally bonded to a magnetic circuit part 2 by laser welding, and an outer circumferential portion 3a is secured to the other open end 1b of a housing 1 to elastically support a magnetic circuit part 2 at the position facing a diaphragm 4.

[0016]

More specifically, a plurality of through-holes 3e for allowing a laser for laser welding to pass through are opened at each equally spaced location in a plurality of places of the annular portion 3c as secured positions in advance as shown in Figs. 4 and 5, the through-holes 3e suitable for the characteristics of a suspension 3 to be mounted and the weight of a magnetic circuit part 2 are selected from these plurality of through-holes 3e, and laser welding is performed while changing laser radiation positions toward them to change the distance between these laser welding positions and an outer circumferential portion 3a of a suspension 3 secured to the other open end 1b of a housing 1, namely the central position of vibration, in order to accurately tune the vibration frequency of a suspension 3 to the desired value.

[0017]

A diaphragm 4 is a vibration plate formed as a circular plate with an appropriate thickness made from an elastic plastic film material, such as polycarbonate, polyetherimide, polyimide, and polyethylene terephthalate. An annular rising portion 4b is formed by bending a portion close to the outer periphery along the inner peripheral surface of a housing 1, and an outer peripheral portion 4a extending from this rising portion 4b is formed in parallel with a flat surface of the other open end 1a of a housing 1.

[0018]

An annular mounting portion 4c is formed in a diaphragm 4 almost in the middle

between the center and the outer periphery of a diaphragm 4, an end surface of a voice coil 5 is bonded to the back face of the mounting portion 4c with adhesive and inserted into an annular magnetic gap 2a, and concentric curved surfaces 4d and 4e swelling outward are formed by bending at the center section and the outer periphery section separated by the coil mounting portion 4c.

[0019]

A voice coil 5 is cylindrically wound of which lead wires 5a are bonded on the back face of the aforementioned diaphragm 4 with adhesive to avoid the effect of vibration as shown in Fig. 2. The distal ends of these lead wires 5a are pulled out toward a terminal block 1d provided to the outside of a housing 1 and are electrically connected to a terminal plate 1e provided to the terminal block 1d by soldering or bonding.

[0020]

The above-described magnetic circuit part 2 is configured by concentrically stacking a yoke 9, a disk-like magnet 10, and a disk-like pole piece 11.

[0021]

A yoke 9, made of a magnetic material, is formed as a cylinder with a bottom. The outer peripheral surface 9a thereof is formed to provide a small gap (for example, 0.05 – 0.2 mm) with the inner peripheral surface of a housing 1. A contact surface 9b facing the annular overhang wall 1f formed in the inner peripheral surface of a housing 1 is in contact with the overhang wall 1f during vibration of a magnetic circuit part 2 to restrict movement of a magnetic circuit part 2 caused by an external shock force.

[0022]

Furthermore in this embodiment, the bottom of a yoke 9 is provided with a raised surface 9c fitting into the central opening 3b of a suspension 3, and the annular portion 3c of a suspension 3 is in contact with and integrally bonded to a support surface 9d formed around the raised surface 9c with adhesive. A counter bore (not illustrated) with a diameter slightly larger than a magnet 10 can be provided in order to position a magnet 10 at the center of the bottom if necessary.

[0023]

A pole piece 11 is formed as a disk with a diameter equal to or larger than a magnet 10. The bottom thereof can be provided with a counter bore (not illustrated) with a diameter slightly larger than a magnet 10 for positioning if necessary. It is preferable that a magnet 10 is retained between this counter bore and the counter bore of a yoke 9 to restrict a radial shift of a magnet 10.

[0024]

Now, the assembly procedures of a multifunction-type vibration actuator A are sequentially described. First, a diaphragm 4 and a voice coil 5 are integrally installed to

a housing 1, a suspension 3 is bonded to a yoke 9 of a magnetic circuit part 2 so as to be integral with the whole magnetic circuit part 2, an annular member 7 is inserted into a cylindrical cover 6 with a bottom, and a member 7 is placed along a side peripheral wall 6a as shown in Fig. 3

[0025]

When a yoke 9 of a magnetic circuit part 2 is bonded to an annular portion 3c of a suspension 3 by laser welding, it is necessary that the characteristics of a suspension 3 to be mounted and the weight of a magnetic circuit part 2 are examined, suitable through-holes 3e are selected, laser welding is performed by changing the laser radiation positions toward these through-holes, and the distance between this laser welding position and the central position of vibration of a suspension 3 and the housing is appropriate in order to accurately tune the vibration frequency of a suspension 3 to the desired value. As a result, it is possible to accurately tune the vibration frequency of a suspension 3 to the desired value during assembly.

[0026]

An outer circumferential portion 3a of a suspension 3 integrally installed to a magnetic circuit part 2 is stacked on this annular member 7, a housing 1 mounted with a diaphragm 4 and a voice coil 5 is placed over them, and an outer circumferential portion 3a of a suspension 3 and an annular member 7 are inserted between the other open end 1b and the aforementioned cover 6.

[0027]

Thus, the lower peripheral side wall 1c of a housing 1 is positioned close to the side peripheral wall 6a of a cover 6 to be fitted with each other, the engaging protrusions 6a and the engaging slits 6b of an engaging means 8 provided to these walls are fitted and engaged with each other, and all the parts consisting of a housing 1, magnetic circuit part 2, suspension 3, diaphragm 4, voice coil 5, cover 6, and annular member 7 are integrally assembled to complete the assembly.

[0028]

Therefore, a suspension 3 can be secured to a housing 1 without using adhesion, molding, or welding, and a shock force from the outside of a housing 1 can be absorbed by compressive deformation of an annular member 7. As a result, fluctuation of characteristics caused by a shock force from dropping can be prevented, and the characteristics of the vibration frequency can be flattened while reducing man-hours and costs. Moreover, changing the size or hardness of an annular member 7 results in the change in the pressure acting on an outer circumferential portion 3a of a suspension 3, leading to easy tuning of the resonant frequency.

[0029]

The invention is not limited to the aforementioned embodiment where a magnetic circuit part 2 is elastically supported by a suspension 3 upward. That is to say, a similar operational effect can be obtained even if the positional relationship between a magnetic circuit part 2 and a suspension 3 is changed such that a suspension 3 hangs a magnetic circuit part 2 to support a magnetic circuit part 2. The construction and the shape of a housing 1, magnetic circuit part 2, suspension 3, diaphragm 4, voice coil 5, cover 6, and annular member 7 are not limited to those shown in the drawings. Only if functions similar to the above are available, any other construction and shape can be applied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Fig. 1 is a cross-sectional front view of a multifunction-type vibration actuator showing one embodiment according to the invention.

Fig. 2 is a reduced top view of the above actuator.

Fig. 3 is a cross-sectional front view of the actuator disassembled based on an assembly procedure.

Fig. 4 is a reduced bottom view showing a magnetic circuit part mounted with a suspension.

Fig. 5 is an exploded perspective view.

DESCRIPTION OF REFERENCE CHARACTERS

[0031]

- | | |
|----|--|
| A | Multifunction-type vibration actuator |
| 1 | Housing |
| 2 | Magnetic circuit part |
| 2a | Magnetic gap |
| 3 | Suspension |
| 3e | Securing planned position (through-hole for laser welding) |
| 4 | Diaphragm |
| 5 | Voice coil |